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ABSTRACT

A study was conducted to determine how research by faculty members is responsive to uncertainty or inadequacy in the environment. The interrelationships among four variables were studied: perceived environmental uncertainty, complexity, boundary spanning activity, and environmental adequacy. It was proposed that the nature of the interrelationships among this set of variables will have important implications for understanding what kind and how much research is done by faculty members. Each of 22 graduate departments was conceptualized as a social system with faculty members as the unit of analysis. Twenty-five interviews were conducted with department chairs, faculty, and administrators at two major midwestern universities, one public and one private. Departments were sampled from the humanities, social, biological, and physical sciences. It is concluded that the certainty with which respondents at the two universities expect to receive grants appears to depend on the excellence of their departments, the developmental history of their department, the rank of the applicant, and the research area involved. Privileged access to the resources clearly reduces perception of environmental uncertainty. (SW)

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FACULTY-ENVIRONMENT INTERDEPENDENCIES IN TWO UNIVERSITIES

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The general objective of this study is to understand how research by faculty members is responsive to uncertainty or inadequacy in the environment. In this study, each of twenty-two graduate departments is conceptualized as a social system. Each department develops an interdependent relationship with its environment based on the unique needs and privileges of its discipline, its members, and the university of which it is a component. Faculty members are the unit of analysis; they may conduct direct exchanges with the environment, the university, or other department members. Within any department there are teaching, research, consultant, boundary spanning, and administrative components in more or less complex arrangements.

The significance of this study lies in two concurrent developments. On the one hand, federal support for research in universities has gone through a ten year period of restricted growth. On the other hand, Light (1974) and Storer (1966) argue that the academic profession strongly supports norms of creativity and communication.

Though the connection between scientific research and American universities began at the end of the 19th century, the orientation of the Federal government until World War II was that the applied purposes served by most research were more properly funded by private foundations and philanthropies than public tax dollars. Governmental and industrial needs for scientific expertise during World War II changed that orientation. The presidents of fifteen major U.S. universities, using data from The National Science Foundation, have recently shown that from 1940 to 1968 the level of federal support for basic scientific research increased twenty-five fold. By 1968, the Federal government's outlay of $2.3 billion represented 70% of all support for basic research. By 1976, however, federal funds represented only 53% of all support for basic research with inflation held constant (Fifteen University Presidents, 1977: 13-14, 26-27).

The constricted source of research support takes on added importance because the personal and professional demand for publications has continued to rise. The importance of research for personal satisfaction and professional rewards has been confirmed in surveys of faculty by Fulton & Trow (1974) and Hind, et al. (1974)

The specific objective of the study is the explication of the interrelationships among four variables: perceived environmental uncertainty, complexity, boundary spanning activity, and environmental adequacy. It is expected that the nature of the interrelationships among this set of variables will turn out to have important implications for understanding what kind and how much research is done by faculty members. Perceived environmental uncertainty is defined as the ability of faculty members to understand and predict the receipt of resources (e.g., money) from the environment and the acceptance of products (e.g., publications) by the environment. A professor's inability to predict the amount or timing of research grants is an example of an uncertain environment. Boundary spanning activity is defined as the institutionalized transfer of resources, especially information, across system boundaries and institutionalized representation of department members to funding or publication sources in the environment. Examples are faculty members' positions as reviewers for foundations or federal funding agencies. Complexity is defined as the degree of differentiation, specialization, and coordination in resource exchanges. Departments are being analyzed by the extent to which there is differentiation and specialization among the faculty and communication among specialties within departments. Environmental adequacy is defined by three resource attributes, the abundance, flexibility, and reproducability of resources; and two environmental characteristics, the ability to develop and barter for necessary resources. Perhaps the most apparent example is the reduction in federal funds available for research in several fields, for example, physics from 1968 to 1976, or the biological sciences from 1972 to 1975 (National Science Founda-

tion, 1978: Table B-3). Environmental adequacy will be measured both objectively and subjectively.

These four variables are arranged in four primary hypotheses:

(1a) The more the environment appears to be uncertain, the more boundary spanning activity there will be by researchers.

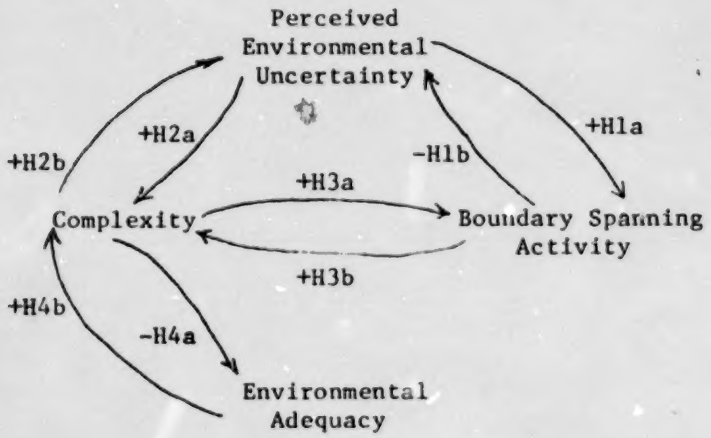
(2a) The more the environment appears to be uncertain, the more complexity there will be in the exchange of resources between departments and funding sources.

(3a) The more complex the exchange of resources between department members and funding sources becomes, the more boundary spanning activity there will be.

(4a) As complexity increases, environmental adequacy decreases.

Each of these hypotheses has a supplement which states a reciprocal relationship between each pair of variables (hypotheses 1b, 2b, 3b, 4b). All hypothesized relationships are depicted in Figure 1.

FIGURE 1



Arrows with a "+" indicate direct variation; arrows with a "-" indicate inverse variation. Some of these relationships are postulated on the basis of research evidence; others are logical theoretical postulations.

Hypothesis 1a: The more the environment appears to be uncertain, the more boundary spanning activity there will be by researchers. There is substantial evi-

dence to indicate that there have been changes in research funding patterns and practices that have made the funding environment seem uncertain. The pattern of support for basic research conducted in universities changed significantly from 1968 to 1978. Smith and Karlesky (1977) recently completed a thorough study of federal support for scientific research and development. Their data included interviews with some 760 administrators, researchers, and graduate students done at 36 universities. In addition, they analyzed data available from the federal government, college and university associations, and the universities themselves. They found that after twenty-five years of expansive funding from World War II to the late 1960s, federal support for research and development has gone through a ten year period of uneven and restricted growth in the research funds of several fields. The practice of government purchases of services, hard bargaining over amounts and terms of funding and negotiation of research topics has reportedly become commonplace (Fifteen University Presidents, 1977; Greenberg, 1967). Though there is no data from studies of higher education, there are studies of marketing (Aldrich & Herker, 1977) and organizational decision-making (Cyert & March, 1963; March & Simon, 1958) that indicate that as environmental uncertainty increases, system members undertake more boundary spanning activity to gather and process information and thereby reduce uncertainty. These findings lead to the expectation that department boundary spanning activities increased from 1968 to 1978 in those areas where funding levels decreased or were uneven in growth.

Hypothesis 2a: The more the environment appears to be uncertain, the more complexity there will be in the exchange of resources between departments and funding sources. This hypothesis is supported by studies demonstrating a link between increasing environmental uncertainty and increasing specialization of organizational environment resource exchanges. Kochan (1975) found that municipal law departments specialized in response to increased activity by public employee unions. Similarly, Wilson (1973) found that corporations have developed specialized public relations units in response to consumer, ecology and other special interest movements. While university

departments are not precisely parallel to unions and law departments, or public relations departments and lobbies, all tend to search their environments for resources that differentially and specifically match their interests or to which they can lay differential and special claim. Such specialization and differentiation usually requires coordination. This evidence and logic leads to the expectation that complexity of exchanges between departments and funding sources in their environment increased from 1968 to 1978 under the conditions mentioned above.

Hypothesis 3a: The more complex the exchange of resources between department members and funding sources becomes, the more boundary spanning activity there will be. Based on preliminary field work, most departments may be characterized by what Thompson (1967) called pooled interdependence. That is, though the success of a department depands on research production, one faculty member's research production is not dependent on another's. There appears to be a second pattern in which reciprocal interdependence characterizes a department. In these departments, research production is dependent on the exchange of resources, particularly information, money, and time, between department members or between subgroups of the faculty. Departments characterized by pooled interdependence are likely to be more differentiated and specialized and so more complex. The complexity requires more intense environmental search and thus higher levels of boundary spanning activity as individual researchers communicate directly with funding sources. By comparison, where faculty work in teams or groups of teams (low complexity) there should be less need for specialized individual lines of communication with funding sources and, therefore, less boundary spanning activity.

Hypothesis 4a: As complexity increases, environmental adequacy decreases. As outlined above, increasing complexity means more specialization and differentiation in a department and in the resource exchanges (e.g., information, technologies, methodologies, sample materials) between the department and funding sources. Thus, environmental resources are strained by increasing complexity unless they increase at rates comparable to increases in complexity. Much of the data cited earlier also

demonstrated that federal, philanthropic, and industrial resources have been inadequate to meet the growing demands of the research community in universities. Changes in the complexity within departments between 1968 and 1978 should parallel changes in support for research and development.

The data reported here are based on twenty-five informant interviews with department chairs, faculty, and administrators at two major midwestern universities--one public and one private. Departments were sampled from the Humanities, Social, Biological, and Physical Sciences. Intensive interviews of 1-1½ hours were done last fall as a preliminary step to the development of a questionnaire for individual faculty members. That questionnaire was distributed to the faculty in seventeen departments at the two universities and preliminary analysis of that data supplements this discussion of the interview data. The scope of the interview included identification of funding sources available to the discipline, the extent to which there were altenrative sources available, the research model used in the discipline, the dependence of the discipline on outside versus university funds, perceptions of changes in funding patterns, the level of research activities in the department, and communication patterns of faculty within and outside their universities.

The central variable in this study is perceived environmental uncertainty. It is composed of three dimensions: (1) the ability of faculty to predict their grants and the conditions attached to them; (2) the ability of faculty to predict the acceptance of their work for publication; and (3) their perceptions of the stability of the criteria by which these two decisions are made by funding agencies and by book or journal editors and publishers. The perceived environmental uncertainty variable rests at the center of the theory that guided this research. Given what was outlined above about the changing financial arrangements between universities and funding sources, it was expected that 1972 was a period of greater perceived uncertainty than 1968, and that by 1978 perceptions of uncertainty about the funding of research were declining to the 1968 levels. Boundary spanning activity and com-

plexity were hypothesized to react to changes in perceived environmental uncertainty.

In terms of their personal experiences, did researchers chose new research questions or develop new specialties because of the changes of availability of research dollars in different research areas? The area of Microbiology, for example, is one of the Life Sciences in which research money for basic research has generally been expanding since 1968. And the success rate of senior and junior faculty at the public university through the 1960s was, according to informants, 100% in getting their first grant proposals funded. But from approximately 1972-1974 there was a "holding period" for NIH and NSF when they funded existing projects but nothing new. During that bad period it was almost impossible for a young person to get a grant. Post docs extended from two years to four years as young scientists could not secure funding independent from senior faculty in their departments. The significance of this uncertainty for research and basic knowledge was manifested in the experiences of young faculty in Microbiology after President Nixon's declaration of war on cancer.

> (After that).... the Cancer Institute at NIH grew at the expense year after year of other NIH departments. For about four years, other NIH budgets were stagnant...When the Cancer Institute bloomed, partly due to tremendous funds going to virol etiology, virologists benefitted from it. It led to a sharp swing in the (Microbiology Department) by young people and some senior faculty to tumor virology.

This kind of development is significant. Many informants recognized a need for science and government to "compromise" and find some working accord so that research that scientists consider essential is funded within affordable levels to the government. Respondents reacted negatively to scenarios in which government agencies dictate research agendas.

Uncertainty appears to be dependent on four new variables not included in the original formulations: (1) department prestige, (2) department development, (3) faculty rank, and (4) the degree of dependence on funding. These new variables represent forms of privileged access to environmental resources.

Seven departments perceived little uncertainty in their funding environment

during the 10 year period of interest. Department informants perceived constant, if not expanding, funding for these departments. They did not recall any increased uncertainty or decrease in funding coincident with the 1972-1974 recession. They were Microbiology, Geophysics, Mathematics, and English at the private university and Chemistry, Physics, and Political Science at the public university. What was common to these departments was a belief that they were excellent departments with top-rated faculty. Their comments were often explicitly positive statements as explanations for their success:

> ...Excellent quality of people and research. Department has excellent reputation of people who've gone on to big things... Continued strong reputation has led to strong recruiting which has meant competitive advantages in funding... (Microbiology - public university).

Other departments proved their excellence through their research:

> I'd say categorically the members of this department are interested in doing the things they want to do and sometimes this means they don't get research funding, but they persist in what they are doing, and what they consider to be important and publishing results and I'd say the results are very good. Sometimes results persuade outside sources to support (Political Science - public university).

A second variable that interacted with perceived environmental uncertainty was departmental development. Two departments at the public university, for example, reported the hypothesized interaction: low uncertainty in 1968, higher uncertainty in 1972, and lower uncertainty in 1978. What was common to these departments was some developmental change. The Physiology department of the public university, for example, went through several changes in the 1970-74 period. In 1970 they were formally associated with a medical school for the first time. That meant the addition of 6-7 junior faculty positions. In addition, because the department was formed in 1949, there were several retirements in this period. The department went through a period of rebuilding coincident with the recession. This was a case of <u>perceived</u> environmental uncertainty. Informant comments indicated that department members were able to secure funding but their perceptions of the likelihood of their success were lowered.

The astronomy department at the public university went through related changes. A new department head began rebuilding their department which had fallen on hard times. He described the "bottom falling out of the federal funding pork barrel" around 1968 and found the public university program needing rebuilding in terms of staff and funding. He began a vigorous recruitment campaign, increased the faculty by 50%, and encouraged faculty to "kick and scream" for appropriate amounts of funding from NSF and NASA to support their work. The situation last year was quite different from that of 1972. In 1978 they had "got a lot of new people who have the credentials to secure money they need."

A third variable related to perceptions of the funding environment is faculty rank. All these interviews were done with senior faculty. But in several interviews young faculty were pictured at a disadvantage. This took several forms. In English at the private university it was the necessity of having one's first book published before national fellowships were available. In Microbiology at the public university it was the probelm of extended post-docs. A representative of that department reported that the post doc is rapidly becoming an institutionalized step between graduate studies and assistant professor status in the biological sciences. During the period of approximately 1970-74, he said, many young researchers found themselves in extended 3, 4, and 5 year post docs as their attempts to secure independent funding were unsuccessful. In Physics at the public university it was manifested in more post docs and fewer assistant professorships during this period. In Geology at the public university faculty rank emerged in a conversation of risk-taking and informational and technological change in the field. Re-tooling or re-directing one's research efforts can take a matter of months or years in the sciences and assistant professors are often unable to indulge in the "luxury" of such time consuming changes. Finally, senior professors discussed the difficulty of getting one's first grant from NSF in particular.

Finally, a fourth variable related to perceptions of changes in funding sources is the degree of dependence on funding. This topic was particularly relevant to dis-

ciplines in the Humanities and some Social Sciences - disciplines characterized by intellect-intensive methodologies rather than experimental or survey methods. Departments of Philosophy, French, Classics at the public university, Music and Romance Languages at the private university indicated that federal dollars were very uncertain and that the number of sources from which grants were available was small (See Table 1). More importantly, however, a different research model was in operation. As a Classics professor said:

> The more typical pattern of research in classics is writing a book and needing ¼ research assistant to do scut work for you. The pattern of the sciences, a research assistant for five years or 4 or 5 research assistants or a full time research assistant, is not applicable. It's interesting because the Humanities decided 15 to 20 years ago that the Sciences has the problem model for scholarship and research. Since then they've been trying to play the same under those rules with principal investigators, teams, and projects that look like those in Chemistry. It's silly. It's not intended to be the same sort of pursuit. And then we wonder why 98% of the funding goes to the Sciences. It has an effect on the prospect of proposals. That's why NEH is a good source; they have a different perspective. (Classics - public university)

When asked about the general form research proposals take, most representatives of other departments in the Humanities echoed his description - a semester or year off, or summer salary, perhaps a modest amount to travel to use some archives or library resources, perhaps a ¼ time research assistant for library or classical assistance, and some secretarial time.

Research financing in the Humanities has followed the general trend. The financial boom ended around 1968 and philanthropies suffered through the recession of 1972-74. The creation of new knowledge in the Humanities has apparently continued as faculty use their own resources, summer and sabbatical leaves. What has hurt the Humanities, and in the long run, perhaps the creation of new knowledge, is the end of most federal fellowships for graduate study. The ranks of the next generation of historians, linguists, and philosophers will reportedly be smaller and the thoughts and the theories they would have created will be postponed or lost. Scholars in the Humanities were optimistic however. They cited the creation of the National Endowment of the Arts and the National Endowment of the Humanities. Though

Table 1
Concentration of Resources for Different Departments

STATE U.	Other HEW	NSF	NASA	NEH/NEA	NIH	NIE	Dpt. ENERGY	DOD	LABOR	GUGGENHEIM	ROCKEFELLER	ACLS	FORD	AMPhilSoci	AMCance	Sloan	INDUSTRY	UNIVers	TOTAL sources/ department
History				X						X	X	X						X	5
Astronomy		X	X															X	3
French				X														X	2
Pol Sci		X		X									X					X	4
Physiology		X	X		X													X	4
Music																		X	1
German				X						X		X						X	4
Education						X												X	2
Classics				X								X		X				X	4
Geology		X																X	2
Chemistry		X			X												X	X	4
Microbiol.		X			X												X	X	4
Physics		X					X	X										X	4
Philosophy					X													X	2
Sociology	X	X			X			X	X		X							X	7
Economics		X							X									X	3
PRIVATE U.																			
Math		X																X	2
Geophysics		X	X					X								X	X		5
Romance											X	X	X					X	4
Microbiol.		X			X		X								X		X		5
English				X						X		X							3
Music										X		X	X						3
Total/ Agency	1	12	3	6	6	1	2	3	2	3	3	6	3	1	1	1	4	18	

they felt that neither has yet fulfilled its funding potential, at least scholars in the Humanities now have their own "ballpark" and "set of rules to play by." (Classics - public university).

In summary the certainty with which respondents at the two universities expect to receive grants appears to depend on the excellence of their departments, the developmental history of their department, the rank of the applicant, and the research area involved. Privileged access to the resources available clearly reduces perception of environmental uncertainty.

There have been some institutional responses to perceived environmental uncertainty which may be worth mentioning. First is the creation of offices at the department and college level to process information concerning the availability of grants from private or government sources. These offices store information on agency requests for proposals and often have systems for matching faculty interests with lists of potential patrons. Some go so far as to prepare partial or complete proposals for professors. These are recent developments but their express purpose is in reducing the uncertainty of the granting process by (1) getting as much information as possible about any grant program, (2) steering information to faculty whose interests match those of funding agencies, (3) maintaining communication with the granting agency, and (4) allowing faculty the assistance to produce a complete and competitive proposal. The other development is the creation of intra-university funding alternatives, particularly for humanities, new faculty, and to provide seed money to make grant proposals to outside agencies more attractive. Uncertainty, thus, did in fact lead to increased boundary spanning activities.

There are some limitations on the data to be noted. First, the respondents represent an arbitrary collection of informants. The goal of the interview phase was to interview as many department representatives as would cooperate until sufficient data was collected to construct the survey. Second, to get some longitudinal perspective senior faculty were interviewed. Many had been full professors for the ten year period and reported being less susceptible to the pressures and uncer-

tainties than their junior colleagues. Third, on several measures these are two of the elite institutions in the country. Many departments surveyed rank in the top 20 according to the American Council of Education rankings (Roose and Anderson, 1970) and have been in that prestigious position for the period of years of this study. Also, these two universities have consistently ranked among the top recipients of federal R & D obligations. (Indeed, that is a very restricted club. Eighteen of the top twenty universities in terms of federal R & D receipts have been there since at least 1963). Finally, these respondents were successful researchers, theorists, and administrators. The sample of respondents whose experience might be more in line with the hypothesized relationships might be those academicians who have been unsuccessful or less successful with funding agencies. Some of these people may be respondents in the survey. Others, however, may have left the university or moved from research positions.

No published evidence of a connection between lack of success in securing grants and either negative tenure decisions or personal decision to leave a research position has been found. A small follow-up, however, of assistant professors who left these two universities is planned to see if there is any connection.

Given the significance of these four new variables to informants--department prestige, department development, faculty rank, and dependence on funding--when the survey data are analyzed, these variables will be studied.

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